Wilson Bull., 107(4), 1995, pp. 675–685

BREEDING BIOLOGY OF A GREY EAGLE-BUZZARD POPULATION IN PATAGONIA

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Abstract.—We studied the breeding performance of a Grey Eagle-Buzzard (*Geranoaetus melanoleucus*) population in a region of northern Argentinian Patagonia where two different habitats occur; the mountains near the Andean cordillera and the plains where shrub-steppes predominate. Mean eagle density was 1 pair/19 km^2 (N = 44), with higher densities occuring in the plains (1 pair/13.2 km^2, N = 17) than in the mountains (1 pair/22.7 km^2, N = 27). We located four communal roosts, with a maximum number of 14 immature birds roosting together. Of 1254 prey items identified from pellets, most were European hares (*Lepus europaeus*) (58.2%), rodents (19.1%), and birds (16.5%). Diet varied between pairs and between those breeding in the mountains and those in the plains. The number of nests per pair was significantly higher in the plains (5.1 nests/pair, N = 9 pairs) than in the mountains (3.2 nests/pair, N = 14 pairs). Breeding success was similar in both breeding seasons. About 80% of the pairs laid eggs and over 60% successfully raised at least one young. The number of fledgling young per pair varied between one and three. The mean number of fledglings per successful pair was 1.8. The values of breeding density and success are the highest published for this species (and among the highest for other large eagles), probably because the species exploits the abundant European hare, a mammal introduced to Patagonia at the beginning of the century. *Received 12 Sept. 1994, accepted 10 May 1995.*

The Grey Eagle-Buzzard (*Geranoaetus melanoleucus*) is the largest Buteoninae, weighing 1670–3170 g (Jiménez and Jaksic 1990). Its range extends from Venezuela to Tierra del Fuego. It prefers open country with steep landscapes. It is seen more rarely in the plains (Brown and Amadon 1968, Jiménez and Jaksic 1990). In Patagonia the Grey Eagle-Buzzard is the largest raptor species, except for Cathartidae, and the birds are relatively undisturbed by man (Donázar et al. 1993). The most significant recent change in the ecology of this region has been the introduction of two lagomorph species: the European hare (*Lepus europaeus*)—introduced in 1888 in central Argentina (Godoy 1963) and around the beginning of this century in our study area (authors unpubl.)—and the European rabbit (*Oryctolagus cuniculus*) that recently (1945–1950) expanded its range across the Argentinian border from Chile (Howard and Amaya 1975). There are few studies on the Grey Eagle-Buzzard, and none have provided quantitative data (see review in Jiménez and Jaksic 1990). Food

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habits of Grey Eagle-buzzards have been reported for some Chilean sites (Schlatter et al. 1980; Jiménez and Jaksic 1989, 1990; Iriarte et al. 1990), but based on few prey items (only one study with more than 100 prey). The breeding biology is almost unknown. There are few records of nest site characteristics and reproductive parameters (see review in Jiménez and Jaksic 1990).

This study provides measurements of population density, feeding habits, and reproductive parameters for a Grey Eagle-Buzzard population occupying a relatively undisturbed area in northern Argentinean Patagonia. Information on nest-site location and orientation has been published elsewhere (Travaini et al. 1994). We compare our results with population parameters from other large eagle populations in regions (mainly Europe) comparatively more disturbed by human activities.

STUDY AREA AND METHODS

We performed this study in the Province of Neuquén, northern Patagonia, Argentina, in a circle of 60–70 km radius centered at the town of Junín de los Andes (39°57′S and 71°05′W, 780 m above sea level). The study area contained two distinct physiographic areas: mountains and plains. The mountains (spurs of the Andean range) occupy the northern and western portions of the study area, with the highest peaks reaching 1600 m. The plains are located in the southeastern part of the study area and are dissected by steep valleys. The weather is cold and dry with a pronounced gradient of rainfall from the mountains (800 mm average annual rainfall) to the plains (300 mm). The area belongs to the Patagonian phytogeographic province, Western District (Cabrera 1976). The vegetation is typically mixed grass and shrubs. Dominant species are *Mullinum spinosum, Senecio* spp., *Stipa* spp., and *Poa* sp. Some of the common woody shrubs are *Chacaya trinervis, Berberis darwinii,* and *Schinus molle.* In the bottom of the valleys there are marsh zones, called "mallines", with dense herbaceous vegetation, where dominant species are *Cortadeira araucana, Juncus* spp., and *Carex* sp. Woody species such as *Maytenus boaria* and *Salix humboldtiana* are frequent in valleys and near mallines, particularly in the mountains.

We conducted this study during the spring and summer (September–February) of two consecutive breeding seasons, 1991–92 and 1992–93. Grey Eagle-Buzzard territories were located by means of personal inquiries to land owners and ranch workers, active searches in a vehicle along main and secondary roads, and cross-country searches on foot. We used binoculars (10 × 40) and spotting scopes (20 to 40×) to check cliffs and other potential nesting sites. The more thorough censuses were done along the valleys of the main rivers, due to the higher density of roads in those places. Roosting sites of juveniles were located by observing juveniles' activity late in the afternoon. During the autumn of 1993 (May) the whole area was searched again to check the status of territories and roosts.

Food habits of breeding eagles were analyzed by using pellets collected throughout the breeding season below nests and perches within territories. Pellets were dried, and their contents were separated. Osseous remains were identified to the lowest taxonomic level possible, using a reference collections (i.e., birds, small mammals) and small mammal skull keys (Pearson 1986). Mammal hair was identified through medula types and scale patterns following the methodology of Brunner and Coman (1974) and the keys of Chehébar and Martin (1989). Each species found in a pellet was considered as one prey item unless there was clear evidence of more than one individual. Biomass contribution of prey items was not calculated. We compared the contents of pellets collected during incubation and the first half of the nestling period (from adult birds only) with pellets collected during the second half of the nestling period and postfledging period (from adult birds and fledged young). We also compared the diet of pairs nesting in the mountains versus those nesting in the plains.

The location of territorial pairs and nest structures was plotted on topographic maps (Scale 1:50,000 and 1:100,000). Unused nest were attributed to the nearest pair holding a territory. We measured the diameter and external depth of the more accessible nests. Non-measured nests were classified in three morphological categories: (1) nests with external depth greater than diameter; (2) nests with the same external depth and diameter; (3) nests with external depth less than diameter. Assuming that the diameter is similar in all the nests (see results), the ratio external depth/diameter provides information concerning the quantity of accumulated nest material.

For estimating number of nests per territory and percent of breeding pairs we used only those territories that we were confident that we had found all the alternative nests. Breeding success was evaluated with the following indices: percent of breeding pairs = number of pairs that laid eggs/number of pairs monitored during the incubation period; mean number of young per pair = number of fledglings/number of pairs monitored; mean brood size at fledging = number of fledglings/number of pairs with fledglings.

RESULTS

Between September 1991 and February 1993 we found 49 territories occupied by pairs of adult Grey Eagle-Buzzards. Fourty-four territories were within the surveyed area, giving an estimated density of 1 pair/19 km^2. Density was higher on the plains (1 pair/13.2 km^2, N = 17) than in the mountains (1 pair/22.7 km^2, N = 27). Mean nearest-neighbor distance was 2081 m in the plains (SD = 916, range = 900–3900, N = 11) and 2964 m in the mountains (SD = 1445, range = 1500–6500 m, N = 14). The 1993 autumn survey indicated that adult birds generally remain in the territory throughout the year. We located four communal roosts of immature Grey Eagle-Buzzards, two of them within the study area. All were located on cliffs at heights ranging from 2 to 100 m above the ground, but occasionally some eagles roosted on the ground. The maximum numbers of immature eagles seen at any one time in each roost were 14, 8, 6, and 2. The two roosts inside the study area were used in both breeding seasons, but no eagles were observed at these roosts in the autumn of 1993.

We observed the eagles' daily routine in two roosts. Young eagles usually left the roost individually in the morning within one hour after sunrise. On two occasions we observed eagles leaving the larger roost in groups (8 and 14 individuals, respectively). The eagles returned individually to their roosts in the late afternoon, starting 4–5 h before dusk. On several occasions we observed the juveniles circling in groups over the roosting area late in the afternoon. During the study, four adult and six immature Grey Eagle-Buzzards were found dead. The cause of death was

TABLE 1

FOOD HABITS OF GREY EAGLE-BUZZARD BREEDING PAIRS AS DETERMINED FROM PELLETS FROM TWENTY DIFFERENT TERRITORIES IN THE ARGENTINEAN PATAGONIA

	Frequency of appearance	Percentage of pairs[a]	Minimum frequency[b]	Maximum frequency[b]
Mammals	80.79	100	61.90	92.80
Chaetophractus villosus	0.08	5	0	0.35
Zaedyus pichiy	0.16	5	0	6.90
Lepus europaeus	58.29	100	33.30	75.90
Rodents	19.16	85	3.10	33.40
Akodon sp.	0.08	5	0	0.35
Phyllotis darwini	0.33	15	0	2.70
Eligmodontia typus	0.08	5	0	1.30
Reithrodon auritus	0.72	25	0	4.50
Ctenomys sp.	2.80	40	0	13.00
Unid. rodent	15.16	80	0	23.20
Galictis cuja	0.40	15	0	1.80
Conepatus chinga	0.25	10	0	2.80
Cervus elaphus	0.08	5	0	2.30
Ovis aries	0.79	30	0	5.50
Unid. mammal	1.60	50	0	6.90
Birds	16.42	100	4.50	28.70
Theristicus caudatus	0.48	10	0	6.80
Anatidae spp.	2.64	40	0	10.75
Milvago chimango	0.08	5	0	0.40
Lophortyx californica	0.16	10	0	2.70
Fulica sp.	0.47	20	0	5.50
Rallidae spp.	0.24	5	0	1.55
Vanellus chilensis	0.48	20	0	3.10
Zenaida auriculata	0.08	5	0	0
Cyanoliseus patagonus	0.16	5	0	0
Colaptes pitius	0.08	5	0	3.40
Turdus falcklandii	0.08	5	0	1.30
Phyrgilus gayi	0.17	5	0	0.45
Sturnella loica	2.07	45	0	16.70
Passeriform spp.	0.88	30	0	8.10
Unid. bird (large size)	0.56	20	0	3.70
Unid. bird (medium size)	1.03	30	0	10.40
Unid. bird	6.69	70	0	16.60
Egg	0.08	5	0	0.40
Reptiles	1.74	40	0	9.50
Iguanidae	0.63	15	0	2.70
Ophidia	1.11	35	0	7.10
Fish	0.08	5	0	0
Salmonidae	0.08	5	0	0

TABLE 1
CONTINUED

	Frequency of appearance	Percentage of pairs[a]	Minimum frequency[b]	Maximum frequency[b]
Invertebrates	0.96	35	0	3.85
Crustacea	0.08	5	0	0.70
Orthoptera	0.16	5	0	2.50
Coleoptera	0.72	25	0	3.85
No. prey	1253			

[a] Percentage of pairs in which a certain prey category was recorded in the diet (N = 20).
[b] Minimum and maximum frequency of appearance recorded considering only the 14 pairs with more than 25 identified prey items.

established in five cases: four were shot and one was caught in a fox leghold trap.

We analyzed 1097 pellets from 26 localities throughout the study area and identified 1253 prey items (Table 1). The European hare (*Lepus europaeus*) accounted for 730 prey items (58.3%), followed by rodents (240 items, 19.2%) and birds (207 items, 16.4%). We also recorded as prey two species of carnivores (the hog-nosed skunk [*Conepatus chinga*] and the grison) [*Galictis cuja*], and occasionally reptiles (snakes and lizards of the family Iguanidae, 1.7%), and invertebrates (1.0%).

To test variation in the diet between the incubation and early nestling period versus the late nestling and postfleging period we analysed data from three pairs for which we had 25 or more prey items in each of the two periods. We considered four prey categories: European hare, rodents, birds, and other prey. Two of the three pairs showed significant differences (χ^2 = 23.724, df = 3, $P < 0.001$, and χ^2 = 13.011, df = 3, P = 0.005): the frequency of European hare in the diet increased during the second part of the breeding season, while the incidence of rodents and birds decreased (Table 2). In the third breeding pair there was a similar although not significant shift in diet (χ^2 = 5.214, df = 3, P = 0.1568).

To study the differences in the diet between pairs in the mountains versus those in the plains we used only the data from the incubation and early nestling period of 11 breeding pairs (8 from the mountains and 3 from the plains) with 25 or more prey items. There were significant differences in the frequency of occurence of the four prey categories considered (European Hare, rodents, birds and other prey) in the diet of eagles in the mountains versus those in the plains (χ^2 = 17.385, df = 3, P = 0.0006) (Table 3). Birds appeared more frequently as prey in the plain compared to rodents that were more frequent in the mountains (Table 3,

TABLE 2

FREQUENCY OF APPEARANCE OF PREY IN GREY EAGLE-BUZZARD PELLETS IN THREE TERRITORIES IN THE MOUNTAINS

	First period[a]			Second period[a]		
	A	B	C	A	B	C
European hare	50.4	45.5	46.6	73.8	76.5	59.2
Rodents	38.5	30.9	13.7	18.9	2.9	15.8
Birds	6.8	16.3	35.7	2.2	8.8	20.8
Other prey	4.3	7.3	4.0	5.1	11.8	4.2
No. prey	234	55	73	137	34	120

[a] Incubation and early nestling (first period) versus late nestling and post-fledging (second period).

$\chi^2 = 11.045$, df = 1, $P < 0.001$). Other prey were also significantly more frequent in the diet of pairs in the plain ($\chi^2 = 6.065$, df = 1, $P < 0.05$), but there were no significant differences in the frequency of European hare ($\chi^2 = 0.275$, df = 1, ns). There were still significant differences among the diets of individual pairs when considering only those nesting in the mountains (N = 8), and three prey categories (European hare, rodents and other prey; $\chi^2 = 86.012$, df = 14, $P < 0.0001$).

We located 101 Grey Eagle-Buzzard nests belonging to 28 different breeding pairs. The number of nests per pair ranged from 1 to 10 ($\bar{x}$ = 4.0, SD = 2.2). Eagles on the plains had a significantly higher number of nests (5.1 ± 2.2, N = 9) than those in the mountains (3.2 ± 2.0, N = 14, Wilcoxon-Mann-Whitney test, Z = 2.167, $P = 0.03$).

Nest dimensions were (N = 5): mean diameter 112.8 cm, SD = 7.0 cm, range = 104–122 cm; mean external depth 47.0 cm, SD = 17.9 cm, range = 20–70 cm. Nest morphology was estimated for an additional 91 nests, 68.1% had a diameter greater than the external depth, 24.2% had

TABLE 3

FREQUENCY OF APPEARANCE OF PREY IN GREY EAGLE-BUZZARD PELLETS IN TERRITORIES IN THE MOUNTAINS (N = 8) VERSUS THOSE IN THE PLAINS (N = 3)

	Mountains	Plains
European hare	51.9	54.3
Rodents	25.9	11.6
Birds	17.2	23.9
Other prey	5.1	10.1
No. prey	588	138

the same diameter and depth, and 7.7% had an external depth greater than the diameter. Nests with external depth the same or greater than diameter occurred significantly more on the plains 41.5% (N = 53) than in the mountains 18.4% (N = 38) ($\chi^2 = 4.422$, df = 1, $P = 0.035$).

Nest situation on the cliff (N = 85) was mainly on ledges (81.2%), vertical crevices (14.1%), and caves (4.7%). Only the 20.0% of the nests had some kind of rocky shelter. None of them were partially or totally concealed by vegetation.

We observed three clutches with two and one with three eggs (mean clutch size = 2.2). The proportion of eagle pairs that laid eggs was 80.9% (17 pairs seen incubating of 21 monitored during incubation). The percentage of pairs with at least one fledgling was 62.8% (N = 43). For the 43 pairs monitored, the mean productivity was 1.1 fledglings/pair/year; 16 pairs did not produce young, seven pairs had one fledgling, 19 pairs two fledglings, and one pair had three fledglings. Consequently, the fledging rate was 1.8 fledglings/successful pair (N = 27).

The number of fledglings per pair was similar in the two years both in the mountains (1991–92: 1.0, N = 6; 1992–93: 0.92, N = 16) and on the plains (1991–92: 1.72, N = 11; 1992–93: 1.33, N = 10) (Wilcoxon-Mann-Whitney test, $P > 0.05$). Pooling the data from the two breeding seasons, we found no significant difference (Wilcoxon-Mann-Whitney test $P > 0.05$) between the breeding success of birds on the plains (1.59, N = 21) and those in the mountains (0.87, N = 22). Human disturbance of reproduction was observed in only one case at a nest located on top of a power pole: it was removed with its contents (probably young nestlings) during maintenance tasks.

DISCUSSION

This study provides the first quantitative data on Grey Eagle-Buzzard population densities. Our density figures are in the higher ranges of those reported for large eagle species in the most favorable habitats (see Newton 1979). Jaksic and Jiménez (1986) suggest that the recent Grey Eagle-Buzzard population increase in southern Chile might be due to an increase in available prey (European rabbit and hare) and deforestation. In our study area, there has been no recent deforestation, but there has been a marked increase in the number of hares, which may well account for the high Grey Eagle-Buzzard density. In Europe the highest densities of large birds of prey are found in Mediterranean areas, where lagomorph densities are high (Soriguer 1981, Blondel and Badan 1976, Donázar 1988).

According to Jiménez and Jaksic (1990) the Grey Eagle-Buzzard has diminished in number in northern and southern Argentina because of secondary poisoning directed at controlling Culpeo Fox (*Dusicyon cul-*

paeus) and Crested Caracara (*Polyborus plancus*) populations. On the contrary, data from our study site and observations made while traveling to other places in Patagonia indicate that Grey Eagle-Buzzards are still abundant in Argentina (unpubl. data). In addition to the presence of exotic lagomorphs, there has been a drop in the use of strychnine in favor of more selective techniques of predator control (von Thungen 1991). We found few cases of direct attack on eagles by ranchers or their employees. The eagle conservation status may continue to improve because people are becoming more willing to believe that raptors play an important role in controlling diseases and rabbit populations. The European rabbit entered continental Argentina from Chile crossing the Andean range (Howard and Amaya 1975) and it is currently spreading close to the study area. In adjacent areas some claim that the rabbit causes severe damage to natural pastures, reducing food available to livestock (Amaya and del Valle 1983, Bonino and Amaya 1985).

Although many species of scavenging raptors use communal roosts at certain stages of their life (Newton 1979, Ceballos and Donázar 1990, Hiraldo et al. 1993), large eagle species generally do not (despite the scavenging habits of juveniles of these species, see Newton 1979). However, juveniles Grey Eagle-Buzzards proved an exception to this general rule: they formed communal roosts in our study area in spring-summer and were frequent visitors at hare and sheep carcasses (unpubl. data). Communal roosts are unusual among the members of the Buteoninae, the habit having been reported to our knowledge only for the Rough-legged Buzzard (*Buteo lagopus*) in winter (Freeman 1952).

In the study area, the Grey Eagle-Buzzard did not show a tendency to prey heavily upon birds and rodents, contrary to the findings of Jiménez and Jaksic (1990) in Chile. European hare was the most frequent prey item. Birds were preyed upon considerably less and at about the same rate as rodents. Data on the relative abundance of different prey in places were the diet of the Grey Eagle-Buzzard has been studied are not available precluding the possibility of finding a link between availability of prey and dietary preference. The proportion of hares in the diet of the Grey Eagle-Buzzard in our study (58.2%) is among the highest known for large eagles in temperate regions: in Golden Eagle diet, for example, the percentage of hares was 59.1% in Alaska (Ritchie and Curatolo 1982); 46.7% in Italy (Noveletto and Petretti 1980), 37.2% in Montana (McGahan 1968), 39.3% in the Alps (Mathieu and Choisy 1982), and 21.8% in the Pyrenees (Fernández and Purroy 1990). The increase in the proportion of hare in the diet towards the end of the breeding season might be due to an increase in hare density with the season, as it happens in other birds of prey whose diets rely heavily on lagomorphs (Fernández 1987, Donázar 1989). Diet variations among pairs probably reflects differences in habitat composition. In our study area European hare and birds are not homogeneously distributed on the territory, they are much more abundant in "mallin" areas in the bottom of valleys than in arid zones of slopes and high plains (Novaro et al. 1992, unpubl. data).

Most Grey Eagle-Buzzard nests in our study area were on cliffs (92.0%, N = 101; Travaini et al. 1994). It is striking how noticeable these nests can be. Eighty percent of them were located in very exposed sites. No nest was found concealed by vegetation or hidden inside cavities in the rock, contrary to what is commonly observed in other large eagles of temperate regions (Fernández and Leoz 1986). In addition, the Grey Eagle-Buzzard seems to have a relatively high number of nests per breeding pair (mean = 4.0, range = 1–10). The average tends to be in the upper limit of those observed in other populations of big eagles. For example, Golden Eagles in Spain have 2.1–3.3 (Jordano 1981, Fernández and Leoz 1986); in the Alps and the Apennines, 2.4–4.0 (Fasce 1979, Mathieu and Choisy 1982); in Britain 3.1–5.1 (Watson 1957, Brown 1969), and 6.0 in Idaho (Beecham and Kochert 1975). In our opinion, the lack of human harassment of the Grey Eagle-Buzzard population could account for the high number of nests located in exposed locations. In contrast, in Europe, where human persecution has been intense, large eagles may have been forced to nest in more concealed locations (Fernández 1993, Fernández and Leoz 1986). Grey Eagle-Buzzards, like other raptors, may use eyries as territorial markers (Newton 1979). In support to this idea, in the plains, were the eagle density was greater, both the number of nests per breeding pair and the relative size (the relation between external depth and diameter) of the nests was greater than in the mountain zone.

The proportion of pairs that tried to reproduce (80.9%) and those that successfully raised at least one young (62.8%) fall within the range reported for other large eagles (see Newton 1979). Regarding brood size, the only previous data available from five nests in Chile reported one chick per nest in all cases (Jiménez and Jaksic 1990). The Grey Eagle-Buzzards in our study reared one to three chicks, two being the most common number. This suggests that if the species is capable of siblicide behavior, the behavior may be strongly influenced by food availability as occurs in other large eagles and raptors (Delibes et al. 1975, Newton 1979, Gargett 1990).

ACKNOWLEDGMENTS

Miguel Delibes, Alejandro Rodríguez, Obdulio Monsalvo, and Miguel Pineda helped with the field work. Our thanks to the administrators of the Estancias Cerro de los Pinos, Chimehuín, Collun-Có, Collón-Curá, Lolén, Pilolil, and Quemquemtreu, who permitted us to work in their estates. Logistic support was provided by the Centro de Ecología Aplicada del Neuquén (Argentina); we are very thankful to Alejandro del Valle and Antonio Guiñazú for their continuous help, and to Dra. Marta Piantanida and Dr. Jorge R. Navas from the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" for their help with reference collection. Sonia C. Zapata identified mammal species from hair medulla type and scale patterns. Financial support was provided by the Instituto de Cooperación Iberoamericana and the Ministerio de Asuntos Exteriores (Spain) through the Programa de Cooperación Científica con Iberoamérica. Ignacia de Bustamante and William Safranek helped with the English translation.

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